Optimising water use efficiency in western NSW

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Key words

Weed control, crop rotation, crop nutrition, timeliness of operations.

Take home message

While farming can be quite complex, leading growers in any district continually get the basics right. For growers in the Nyngan region, the four main factors required to optimise WUE include sound weed control (in fallows and in crop), rotation of cereal crops with broadleaf break crops or pastures, optimisation of crop nutrition (especially phosphorus and nitrogen) and timeliness of operations.

Weed control

The greatest scope for many producers to increase WUE (and profitability) in western regions is weed control in the fallow phase. Quite often the fallow phase and the cropping phase are looked upon as being two separate components requiring completely different strategies. However, these need to be looked at in less isolation, and instead maximise the potential synergies that exist between the two.

The obvious example is management of fleabane. Growers have had significant issues over recent seasons controlling fleabane in fallows. The most reliable control has generally been from applying glyphosate with a 2,4-D product, followed by an application of paraquat around ten days later. The cost of this total operation is around $25-30 /ha for herbicide costs alone.

The key to controlling fleabane is to not rely solely on the fallow for control, but incorporate a range of herbicide and cultural treatments in the crop phase. This will reduce fallow costs, and just as importantly reduce the water loss from transpiring fleabane plants in the fallow period. The water used by weeds between crop maturity and the first fallow spray should not be underestimated.

The first point of control with fleabane is not knowing which herbicide kills it, but knowing its life cycle. This is the most important and cheapest cultural control strategy you can employ. The majority of the germination of fleabane plants occurs in mid to late autumn, then again in late winter to early spring. While fleabane is a beast to control in the fallow stage, it is a relative minnow when control is implemented at these earlier stages. Figure 1 shows the peak period for fleabane germination through the season, as well as potential control tactics at different points throughout the season.

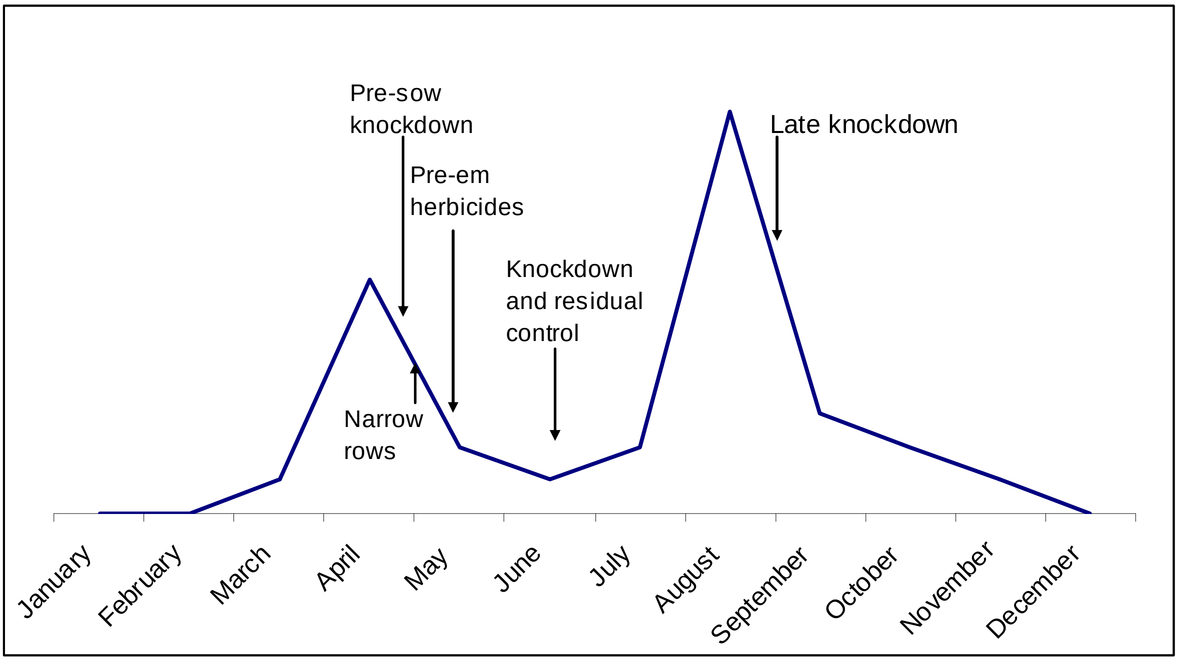

Figure 1: *The majority of fleabane germinations occur in autumn and early spring. Control at these stages will generally be cheaper and more effective than control in the fallow period. In crop control will also ensure that water is not lost through fleabane in the fallow period.*

As far as crop options are concerned, pulses should generally be avoided on paddocks with high fleabane pressure, as there are no in-crop options in case pre-emergent herbicides fail. Canola offers the potential for at least moderate control. Triazine tolerant canola varieties, while generally not as high yielding as other canola varieties, offer significant benefits for the management of problem weeds both in-crop and in the subsequent fallow phase.

A disadvantage of canola regarding overall water use efficiency is that even small amounts of harvest losses can lead to extremely weedy fallows. Control of self sown plants needs to be swift, as these weeds use significant quantities of moisture each day. There may be advantages in applying residual herbicides to canola paddocks directly after harvest to reduce the germination of canola plants. Figure 2 from Coonamble in 2011 highlights the importance of timely fallow management following canola.

Figure 2: *2011 wheat crop sown over the top of a 2010 Brassica trial. The patches with no crop were planted to plots of canola in 2010 while the patches where the crop is actively growing were planted to mustard. The difference was that the mustard plants did not shatter pre-harvest to the same extent as the canola, resulting in less self sown plants to use water in the early fallow phase and more water stored in the fallow for the subsequent crop.*

Norris (1996) describes a formula that can be used for estimating water use by weeds. For C_3 plants (e.g. canola, wheat, fleabane, milk thistle) water use (mm) = (666 * biomass kg/ha)/10000. For example canola growing after a fallow may grow about 500 kg/ha dry matter after 2 weeks, with this growth using 33 mm of water.

Hunt and Kirkegaard (2011) report that for Nyngan there is an average profit of $140/ha where a complete summer weed control program is implemented, with this representing a return of investment for summer weed control of 353 %. There are few other cropping operations that come close to this level of return on investment. This work only takes into account the effects of soil water and not the effects of nutrients.

As well as the effects on soil water, McMaster *et al.* (2010) found that a two week delay in spraying summer weeds reduced the available nitrogen in the soil by 21 kg/ha, compared to where weed control was complete. This amount equates to approximately 45 kg/ha of urea, which at a landed urea price of $650/tonne represents a cost required for the subsequent wheat crop of $29/ha. In effect the cost of timely fallow weed control is likely to be recuperated from the benefit to soil nutrition alone even before taking water into consideration, making the estimates of return on investment reported by Hunt and Kirkegaard (2011) potentially lower than what may be the case when nutrients are taken into account.

A standard rule for summer weed control is that a producer needs to be able to control weeds on the entire fallow area in five days. With limited hours of suitable spraying conditions in summer, this roughly equates to needing to spray the entire fallow in 40-50 hours. For a grower with 4000 hectares to spray, machinery and labour needs to be capable of 80-100 hectares an hour. In situations where this is not possible, further labour, machinery upgrades or the use of contractors may help increase capacity, or a pasture phase may reduce the pressure on fallow spraying and increase the rate of return on the cropped country.

A further issue with regard to summer fallow management is the grazing of crop residues by livestock. A report by Bell *et al.* (2011) says that while there may be small effects of stock on surface compaction and infiltration rates, there generally appears to be little effect on subsequent crop yield. However there are two main reasons why the grazing of summer fallows may lead to yield loss in a farm situation. The first reason is that often the grazing of crop residues results in poor fallow weed control and subsequent lower levels of stored water for the following crop. The second reason is that livestock may remove crop residues, resulting in increased evaporation rates following rainfall events which may in turn reduce sowing opportunities in autumn (see more in *Crop rotation* section).

Crop rotation

The benefits of crop rotation from nitrogen (N) fixation, disease break and weed control are well documented. The relative merit of different rotation crops can also be assessed by looking at the amount of water they extract from the soil profile.

Where subsoil constraints are not a major issue, canola can extract more water from depth than wheat (Figure 32). This difference may become greater in a farm situation, as canola is generally planted earlier than main-season wheat crops.

This greater extraction of canola may be offset to a degree by its relative early maturity in comparison to wheat. Generally canola matures (and is windrowed) approximately two weeks before wheat reaches maturity, so this allows any rainfall in this period to be stored for the subsequent crop.

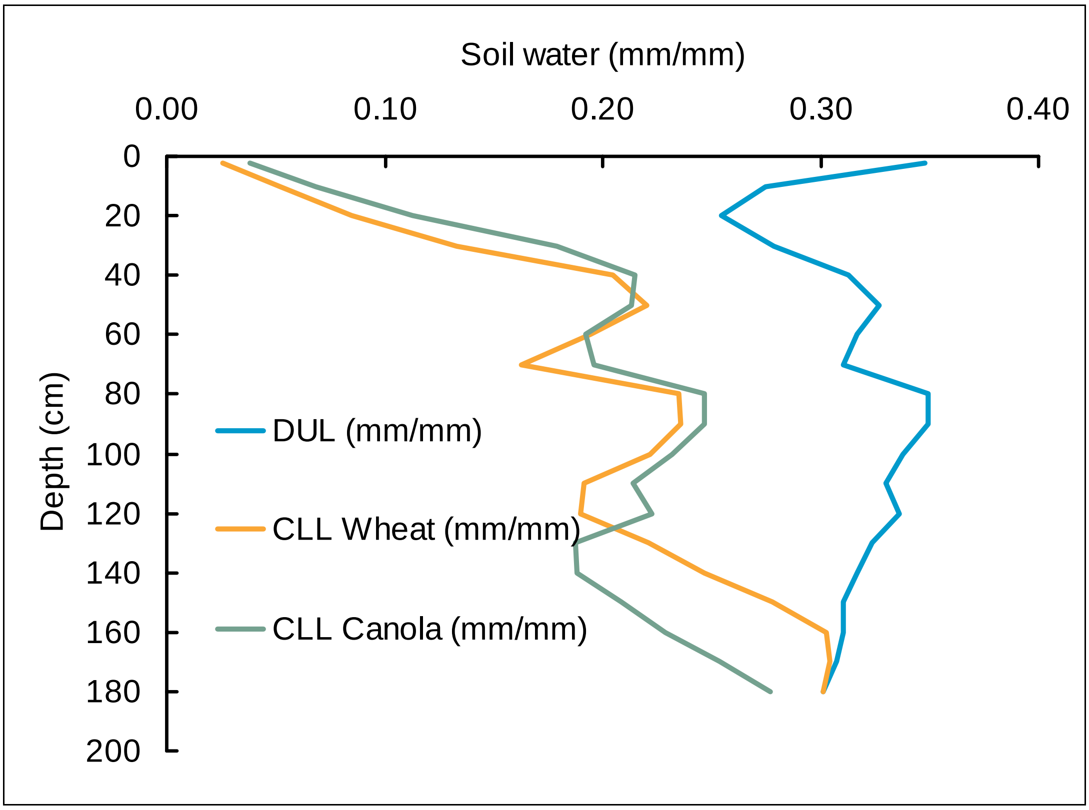

Figure 3: *Where no subsoil constraints are present, canola may extract more water than wheat below 120 cm. In reality this difference could be greater in the Nyngan region as canola is usually planted about two weeks before wheat (source: J Hunt CSIRO).*

Chickpeas are likely to extract less water than wheat or canola, as their later sowing reduces the overall rooting depth. This reduced water use relative to canola provides one major rotational advantage of chickpeas, as the water not utilised by the chickpea crop can be used in reproductive stages of the subsequent wheat crop. While chickpeas may mature relatively evenly on red ground around Nyngan, desiccation should still be considered as the process will stop water use of remaining green shoots and clean up weed escapes, effectively acting as the first fallow spray.

The other main rotation option for the Nyngan region is barley. Barley has often been looked upon as being the 'poor cousin' of wheat; however barley should not be looked upon as a crop that can be grown in place of wheat in a sound rotation, but instead as a crop that compliments wheat in the rotation. The main fit for barley is as a second cereal crop in a crop rotation.

Barley brings a good level of risk management to a crop rotation. A high proportion of broadleaf crops in a rotation at Nyngan will expose producers to a high level of risk, but on the other hand back to back wheat crops also pose a high level of risk for different reasons. Barley has the option to be sown for grain production alone, or potentially be grazed and then locked up for grain. There have been significant breeding advancements in barley in recent seasons, with the variety Hindmarsh having the highest WUE of any cereal crop at low-moderate soil moisture levels (highlighted in Table 1) and the malt variety Buloke offering a significant yield advantage over Schooner and now also a price premium.

Table 1: *Yield and harvest index of three barley varieties in a trial at Trangie in 2009.*

	Yield (t/ha) and Harvest index					
Variety	**30-Apr**		**18-May**		**18-Jun**	
Buloke	2.42	0.25	1.96	0.3	1.96	0.33
Commander	1.64	0.18	1.33	0.19	1.19	0.2
Hindmarsh	2.98	0.33	2.44	0.37	2.31	0.44

Crop nutrition

Research has shown that canola is better able to extract phosphorus (P) from soil than wheat (Bolland and Brennan 2008) meaning that maximum yield of canola can be achieved with lower P application than is required for wheat. This needs to be taken into account for subsequent wheat crops, as anecdotally the greatest response to applied P in wheat is where it is sown following a canola crop. It has been suggested in the past that this is due to canola being a non-host of VAM, however it appears from the research that the response of P in the following wheat crop is due to the ability of canola to scavenge for P. Also, the high level of P response in the wheat crop following canola may simply be due to greater yield potential (i.e. due to reduced disease levels). It is assumed that hybrid varieties with their increased vigour would be better able to scavenge soil P, resulting in greater efficiency of that crop but also a greater P requirement in the following cereal crop.

Planting crops that convert atmospheric nitrogen into plant available forms is a major part of maintaining crop nutrition in western environments, as the application of N (as urea or other forms) is relatively risky. The amount of nitrogen fixed by pulse crops is related largely to the amount of nitrogen in the soil at sowing, the amount of dry matter grown by the crop, and the proportion of N taken away as grain.

Pasture legumes also fix significant quantities of nitrogen, and there may be more scope in western regions to add short-term lucerne phases into a cropping rotation where livestock infrastructure is available. Since the amount of N fixed is related to the amount of N in the soil, the proportion of nitrogen in a lucerne plant that is derived from fixation will be greatest in the first 1-2 years of the pasture phase when soil N levels are low. One perceived disadvantage of lucerne has been the extraction of water from deep in the soil profile. A short term lucerne phase may reduce this deep extraction, allowing a shorter fallow period before planting a subsequent grain crop.

Timeliness of operations

The importance of timeliness has been highlighted in terms of fallow and in crop weed control; however timeliness is important through all cropping operations. Timeliness of sowing is regularly highlighted as being important for profitability (Table 2) and it is in this aspect where no-till farming has its greatest advantage.

The overall effect of stubble retention on water storage in a fallow is greatest where rainfall is regular, i.e. events within 3 weeks of each other. The benefit of stubble residues is greatest in the autumn period (Verburg *et al.* 2004) when evaporative demand is lower than in summer. In effect the stubble residue reduces the rate of water loss from the soil but not the total amount of water that may be lost. This may allow a wider planting window following autumn rain where stubble is retained.

Rotation crops generally have less crop residue remaining after harvest than cereal crops, so the cereal residue from the previous crop can add to the amount of residue through the fallow period.

Table 2: *Average yield loss of wheat when sown later than the optimum sow date for a range of yield levels (source: McDonald, 2009).*

Yield category (kg/ha)	Number of data sets	Mean maximum yield (t/ha)	Yield loss per week	
			%	t/ha
<1.50	4	1.09	11.5	0.116
1.50-2.00	6	1.73	12.2	0.209
2.00-3.00	15	2.31	7.8	0.178
3.00-4.00	8	3.35	8.7	0.285
4.00-5.00	9	4.34	4.5	0.197
>5.00A	9	6.20	4.0	0.239

Other factors to consider

There are other factors that may help in overall water use efficiency of a farming system such as controlled traffic farming, changing from tines to discs, variable rate nutrition and updating crop varieties. While these practices can certainly add significantly to overall profitability, they are only useful where weed control, crop rotation, crop nutrition and timeliness of operations are all optimised.

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